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Practitioner's Docket No. ___915-007.053___   *PATENT*

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of: D.AKOPIAN et al. Group No.:   3661
Application No.: 0 10/ 693,332
Filed: October 24, 2003   Examiner: To Be Assigned
For: Validation of Beacon Signals

Assistant Commissioner for Patents
Washington, D.C. 20231

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Attached please find the certified copy of the foreign application from which priority is claimed for this case:

Country:	International/WIPO
Application Number:	PCT/IB02/04424
Filing Date:	October 24, 2002

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James A. Retter

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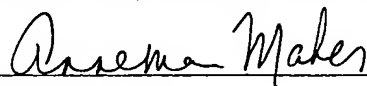Tel. No. (203) 261-1234   Ware, Fressola, Van Der Sluys & Adolphson LLP

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International Application No.⎫
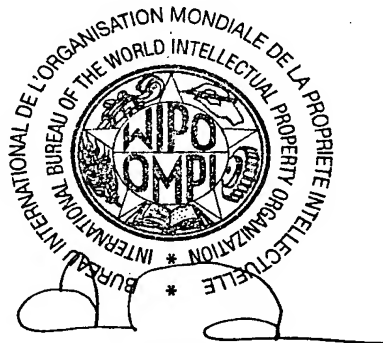Demande internationale n° ⎭ **PCT/IB02/04424**

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07 November 2003
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International Bureau of the
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PCT REQUEST

020875WO

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0	For receiving Office use only	
0-1	International Application No.	PCT / IB 0 2 / 0 4 4 2 4
0-2	International Filing Date	2 4 OCTOBER 2002 '2 4. 10. 02
0-3	Name of receiving Office and "PCT International Application"	INTERNATIONAL BUREAU OF WIPO PCT International Application

0-4	Form - PCT/RO/101 PCT Request	
0-4-1	Prepared using	PCT-EASY Version 2.92 (updated 01.06.2002)
0-5	Petition	
	The undersigned requests that the present International application be processed according to the Patent Cooperation Treaty	
0-6	Receiving Office (specified by the applicant)	International Bureau of the World Intellectual Property Organization (RO/IB)
0-7	Applicant's or agent's file reference	020875WO
I	Title of invention	VALIDATION OF BEACON SIGNALS
II	Applicant	
II-1	This person is:	applicant only
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V	Designation of States	
V-1	Regional Patent (other kinds of protection or treatment, if any, are specified between parentheses after the designation(s) concerned)	AP: GH GM KE LS MW MZ SD SL SZ TZ UG ZM ZW and any other State which is a Contracting State of the Harare Protocol and of the PCT EA: AM AZ BY KG KZ MD RU TJ TM and any other State which is a Contracting State of the Eurasian Patent Convention and of the PCT EP: AT BE BG CH&LI CY CZ DE DK EE ES FI FR GB GR IE IT LU MC NL PT SE SK TR and any other State which is a Contracting State of the European Patent Convention and of the PCT OA: BF BJ CF CG CI CM GA GN GQ GW ML MR NE SN TD TG and any other State which is a member State of OAPI and a Contracting State of the PCT
V-2	National Patent (other kinds of protection or treatment, if any, are specified between parentheses after the designation(s) concerned)	AE AG AL AM AT AU AZ BA BB BG BR BY BZ CA CH&LI CN CO CR CU CZ DE DK DM DZ EC EE ES FI GB GD GE GH GM HR HU ID IL IN IS JP KE KG KP KR KZ LC LK LR LS LT LU LV MA MD MG MK MN MW MX MZ NO NZ OM PH PL PT RO RU SD SE SG SI SK SL TJ TM TN TR TT TZ UA UG US UZ VC VN YU ZA ZM ZW
V-5	Precautionary Designation Statement In addition to the designations made under items V-1, V-2 and V-3, the applicant also makes under Rule 4.9(b) all designations which would be permitted under the PCT except any designation(s) of the State(s) indicated under item V-6 below. The applicant declares that those additional designations are subject to confirmation and that any designation which is not confirmed before the expiration of 15 months from the priority date is to be regarded as withdrawn by the applicant at the expiration of that time limit.	
V-6	Exclusion(s) from precautionary designations	NONE
VI	Priority claim	NONE
VII-1	International Searching Authority Chosen	European Patent Office (EPO) (ISA/EP)

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VIII	Declarations	Number of declarations	
VIII-1	Declaration as to the identity of the inventor	–	
VIII-2	Declaration as to the applicant's entitlement, as at the international filing date, to apply for and be granted a patent	–	
VIII-3	Declaration as to the applicant's entitlement, as at the international filing date, to claim the priority of the earlier application	–	
VIII-4	Declaration of inventorship (only for the purposes of the designation of the United States of America)	–	
VIII-5	Declaration as to non-prejudicial disclosures or exceptions to lack of novelty	–	
IX	Check list	number of sheets	electronic file(s) attached
IX-1	Request (including declaration sheets)	5	–
IX-2	Description	17	–
IX-3	Claims	4	–
IX-4	Abstract	1	EZABST00.TXT
IX-5	Drawings	1	–
IX-7	TOTAL	28	
	Accompanying items	paper document(s) attached	electronic file(s) attached
IX-8	Fee calculation sheet	✓	–
IX-17	PCT-EASY diskette	–	Diskette
IX-19	Figure of the drawings which should accompany the abstract	1	
IX-20	Language of filing of the international application	English	
X-1	Signature of applicant, agent or common representative		
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X-1-2	Name of signatory	Dr. Ralph Schippan	
X-1-3	Capacity	Patent Attorney	

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10-1	Date of actual receipt of the purported international application	2 4 OCTOBER 2002	(2 4. 10. 02)
10-2	Drawings:		
10-2-1	Received		
10-2-2	Not received		
10-3	Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application		
10-4	Date of timely receipt of the required corrections under PCT Article 11(2)		
10-5	International Searching Authority	ISA/EP	

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10-6	Transmittal of search copy delayed until search fee is paid	

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11-1	Date of receipt of the record copy by the International Bureau	

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Validation of beacon signals

FIELD OF THE INVENTION

The invention relates to a method for validating detected code modulated signals transmitted by beacons of a positioning system and received by a receiver of the positioning system. The beacon signals are detected based on a correlation procedure performed between a respective given code for a specific beacon and received beacon signals. The invention relates equally to a corresponding receiver, to an electronic device comprising such a receiver, to a device cooperating with such a receiver and to a corresponding positioning system.

BACKGROUND OF THE INVENTION

A well known positioning system which is based on the evaluation of signals transmitted by beacons is GPS (Global Positioning System). The constellation in GPS consists of more than 20 satellites employed as beacons that orbit the earth. The distribution of these satellites ensure that usually between five and eight satellites are visible from any point on the earth.

Each of the satellites, which are also called space vehicles (SV), transmits two microwave carrier signals. One of these carrier signals L1 is employed for carrying a navigation message and code signals of a standard positioning service (SPS). The L1 carrier signal is modulated by each satellite with a different C/A (Coarse Acquisition) Code. Thus, different channels are obtained

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for the transmission by the different satellites. The C/A code, which is spreading the spectrum over a 1 MHz bandwidth, is repeated every 1023 chips, the epoch of the code being 1 ms. The carrier frequency of the L1 signal is further modulated with navigation information at a bit rate of 50 bit/s. The 50 Hz data bit stream of the navigation message is aligned with the C/A code transitions. The navigation information comprises in particular orbit parameters like ephemeris data. Ephemeris parameters describe short sections of the orbit of the respective satellite. Based on these ephemeris parameters, an algorithm can estimate the position and the velocity of the satellite for any time of about 2-4 hours during which the satellite is in the respective described section. Ephemeris data also comprise clock correction parameters which indicate the current deviation of the satellite clock versus a general GPS time. Further, a time-of-week TOW count is reported every six seconds as another part of the navigation message.

A GPS receiver of which the position is to be determined receives the signals transmitted by the currently available satellites, and a tracking unit of the receiver detects and tracks the channels used by different satellites based on the different comprised C/A codes. In order to be able to detect the channels used by different satellites, the receiver has access to a replica of the C/A codes employed by each of the satellites. The receiver is thus able to compare the available C/A codes with the C/A codes in the received signals in a correlation procedure.

By evaluating measurements on the tracked signals, the receiver first determines the time of transmission of the

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ranging code transmitted by each satellite. Usually, the
estimated time of transmission is composed of two
components. A first component is the TOW count extracted
from the decoded navigation message in the signals from
the satellite, which has a precision of six seconds. A
second component is based on counting the epochs and
chips from the time at which the bits indicating the TOW
are received in the tracking unit of the receiver. The
epoch and chip count provides the receiver with the
milliseconds and sub-milliseconds of the time of
transmission of specific received bits. A detected epoch
edge also indicates the code phase of a received signal.

Based on the time of transmission and the measured time
of arrival TOA of the ranging code at the receiver, the
time of flight TOF required by the ranging code to
propagate from the satellite to the receiver is
determined. By multiplying this TOF with the speed of
light, it is converted to the distance between the
receiver and the respective satellite. The computed
distance between a specific satellite and a receiver is
called pseudo-range, because the general GPS time is not
accurately known in the receiver. Usually, the receiver
calculates the accurate time of arrival of a ranging code
based on some initial estimate, and the more accurate the
initial time estimate is, the more efficient are position
and accurate time calculations. A reference GPS time can,
but does not have to be provided to the receiver by a
communications network.

The computed distances and the estimated positions of the
satellites then permit a calculation of the current
position of the receiver, since the receiver is located
at an intersection of the pseudo-ranges from a set of

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satellites. In order to be able to compute a position of
a receiver in three dimensions and the time offset in the
receiver clock, the signals from at least four different
GPS satellites are required.

If navigation data are available on one of the receiver
channels, the indication of the time of transmission
comprised in a received signal can also be used in a time
initialization for correcting a clock error in the
receiver as the internal receiver clock is generally
biased.

Currently, most GPS receivers are designed for outdoor
operations with good signal levels from satellites.

In case of bad reception conditions, e.g. indoors, the
tracking of signals is less reliable with such receivers.
One of the problems is the cross-correlation effect
between the satellites. When searching for a specific
satellite signal, often an undesired cross-correlated
signal from another satellite will be found. The signal-
to-noise ratios of signals from different satellites vary
within a wide range indoors, as the satellite signals
undergo different attenuation. This implies that the
signal from one satellite may be quite strong, while the
signal from another satellite is rather weak. At the same
time, the pseudonoise properties of the satellite signals
provide only a limited selectivity during the correlation
process. Signals from wrong satellites and code-phases
are only attenuated by around 20dB in the correlation
procedure. Thus, if the differences in the signal-to-
noise ratio of the different satellite signals are higher
than this attenuation, then the signal from wrong
satellites could interfere with a given channel. That is,

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a wrong satellite signal with a high signal level can be determined in the correlation procedure to be the desired satellite signal, in case the correct satellite signal has a low signal level. This makes the normal tracking impossible.

In a known approach aimed at avoiding a wrong tracking, only those satellites are considered which have a limited difference in their signal-to-noise ratios. This approach has the disadvantage, however, that the receiver will often not be able to calculate the position when only signals from few satellites are received, which is the most probable scenario indoors.

A known system called RAIM (Receiver Autonomous Integrity Monitoring), which is employed in airplanes, studies whether the measurements on tracked satellites are correct. However, RAIM is designed for use in good signal conditions and requires moreover reception of signals from at least 5 satellites.

SUMMARY OF THE INVENTION

It is an object of the invention to enable a reliable detection of a sufficient number of beacon signals also under weak signaling conditions.

This object is reached with a method for validating detected code modulated signals transmitted by beacons of a positioning system and received by a receiver of said positioning system, which beacon signals are detected based on a correlation procedure performed between a respective given code for a specific beacon and received beacon signals. The proposed method comprises in a first

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step performing measurements for the detected beacon
signals. At least one of the detected beacon signals is
then selected as calibration signal. Based on
measurements for the detected calibration signal and on
an available reference position of the receiver, at least
one allowed range for the results of measurements for the
other detected beacon signals is determined. Each
detection of a beacon signal for which results of
performed measurements are outside of a range determined
for these measurements is rejected. It is to be noted
that the range determined for a specific kind of
measurements may also be composed of several sub-ranges.
Further, a determined allowed range may comprise only a
single value. It is understood that the order of the
proposed steps can partly be varied.

The object is further reached with a receiver, with an
electronic device comprising a receiver or with some
other device, either comprising means for carrying out
the steps of the proposed method. In case the processing
is performed in another unit than the receiver, the
required information about the received signals is
forwarded by the receiver to this unit. The proposed
other device can be for instance a network element of a
network. The object is also reached with a system
comprising a receiver and a device, in which system
either the receiver or the device comprises means for
carrying out the steps of the proposed method. In case
the receiver performs the processing, the device may
provide assistance data to the receiver required for the
verification of the detected beacon signals.

The invention proceeds from the idea that the signal of a
beacon which can be assumed to be detected correctly can

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be used for validating the detection of other beacon
signals, i.e. for studying after the correlation
procedure whether an already acquired beacon is
recognized as correct beacon. Even in bad signaling
conditions, one such beacon which can be assumed to be
detected correctly will usually be found without
problems. Measurements on the signals from this beacon
signal can be used for bounding one or more measurements
from the other beacons. If measurement results are
outside of the specified range, then the respective
beacon signal is supposed to be detected wrongly. It is
understood that the measurements may comprise direct
measurements, including the extraction of data from
received signals, and a calculation of parameters based
on such measurements.

It is an advantage of the invention that it allows to
detect a large percentage of received beacon signals and
to determine among the detected beacon signals a large
percentage of wrongly detected signals.

The invention thereby allows to calculate the position of
the receiver in bad propagation conditions also when only
signals from few satellites are available which have a
high difference in the signal-to-noise ratio. Thus, the
probability that a positioning can be performed is
increased and the determined position is also more
accurate due to the rejection of wrongly detected
signals. Furthermore, also other errors which affect the
accuracy of the positioning can be reduced.

It is moreover an advantage of the invention that it is
easy to implement.

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Preferred embodiments of the invention become apparent
from the dependent claims.

For the reference position of the receiver, a rather
coarse knowledge of the receiver position is sufficient.
Such a coarse knowledge might be available for example,
in case the position was calculated recently.
Alternatively, the receiver could be an assisted
receiver, which receives an indication of the reference
position from another unit. For example, the position of
a base station of a mobile communication network to which
the receiver is currently connected might be used as
reference position. In case the processing is carried out
in a unit external to the receiver, the reference
position is either available at this unit or supplied to
this unit.

Also other available assistance data can be used for
determining the range for some measurements. Such other
assistance data may be in particular orbit parameters.

Various kinds of measurements are suited for determining
whether they lie in a determined range.

Preferably, the method according to the invention is
employed at least for verifying whether a determined time
of transmission of the detected signals or a sub
component of this time of transmission lies within an
acceptable range. That is, the code phase of the detected
signals is checked.

Another measurement which is suited for the verification
relates to the frequency shift in the detected signals at
the receiver due to the Doppler effect. For the

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verification, it can be determined whether the entire
frequency or a determined frequency shift lies in an
acceptable range.

In case ephemeris and time information is available, and
in addition the reference position is known with an
accuracy of 3km, then 90% of wrongly cross-correlates
satellites can be recognized by verifying the code phase
of a detected signal. If the Doppler frequency is
verified in addition to the code phase, even more than
90% of wrongly cross-correlated satellites can be
recognized. In case the reference position is known with
an accuracy of 30km, still more than 50% of wrongly
cross-correlated satellites can be recognized by
verifying the code phase and the Doppler frequency.

The code modulated beacon signals may be detected in a
tracking process, but equally in any other type of
process, e.g. in a snapshot data processing. Further, the
measurements results employed in the method according to
the invention may originate from a tracking process or
from some other process.

Preferably, though not necessarily, the method according
to the invention is implemented as software.

The beacons can be in particular, though not exclusively,
satellites or a base stations of a network.

Preferably, though not necessarily, the receiver is a GPS
receiver and the beacons are GPS space vehicles. The
invention can be employed as well for instance in future
extended GPS systems with new signals, in particular the
planned new L2C (L2 civil) signal and the planned new L5

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signal, and in other similar beacon based positioning systems such as Galileo. The L2C signal and the L5 signal are presented for example in the document "The Modernized L2 Civil Signal" in GPS World, September 2001, by Richard D. Fonata, Way Cheung, and Tom Stansell.

BRIEF DESCRIPTION OF THE FIGURES

Other objects and features of the present invention will become apparent from the following detailed description considered in conjunction with the accompanying drawings. The only figure, figure 1, is a flow-chart which illustrates an embodiment of the method according to the invention.

DETAILED DESCRIPTION OF THE INVENTION

The flow chart of figure 1 illustrates an embodiment of a method for validating a tracking of satellite signals according to the invention.

The method is implemented as a software algorithm in a processing unit of a GPS receiver of a GPS positioning system. Several satellites SV of the GPS system transmit C/A code modulated signals as described above. The signals transmitted by the satellites are received by the GPS receiver and tracked by a tracking unit of the receiver. The GPS receiver is moreover integrated in a mobile terminal which is able to communicate via the air interface with a base station of a communication network. Currently, the GPS receiver is located indoors.

The tracking unit of the GPS receiver may be a conventional tracking unit which is able to detect and

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track received satellite signals based on a correlation
procedure. In the correlation procedure, a code which is
available for a respective satellite is compared with
received signals. The signal resulting in the best
correlation is supposed to originate from the respective
satellite.

In addition, the tracking unit is able to provided for
each tracked satellite signal a subcomponent T_{Ms} of the
time of transmission of the respective ranging code. Each
subcomponent T_{Ms} is a sub M seconds component of the time
of transmission. In case the tracking unit is able to
perform a bit-synchronization on the received signals,
the subcomponent is a sub 20ms (M=0.020) component of the
time of transmission, i.e., the difference between the
time of transmission of the last detected bit edge and
the time of transmission of the ranging code. Otherwise,
the measurement is based on a chip count for the received
signals, resulting in a sub 1ms (M=0.001) component. In
the latter case, the subcomponent corresponds to the
difference between the time of transmission of the last
detected epoch edge and the time of transmission of the
respective ranging code.

Since the GPS receiver is currently located indoors, it
detects and tracks signals from N+1 satellites with
significantly different signal-to-noise ratios.

For the proposed method, it is moreover assumed that
certain parameters are available at the GPS receiver.

One of these parameters is an initial reference position
P_{init} of the GPS receiver. The initial reference position
may be for example the position of a base station to

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which the mobile terminal comprising the GPS receiver is
currently connected. In this case, the initial reference
position P_{init} could be communicated to the GPS receiver by
this base station. The initial reference position has an
equally known maximal possible error dP_{max}.

Further, it is assumed that the base station of the
mobile communication network provides the GPS receiver
with assistance messages comprising orbit parameters for
the satellites by which the tracked signals are supposed
to be transmitted.

Finally, an initial estimate of the time of flights T_{TOF}
of the signals from the satellites to the GPS receiver is
set to $T_{TOF}=0.070ms$

The proposed method functions as follows.

In a first step, the tracked satellite signal with the
strongest signal level is determined in a processing unit
of the receiver. This satellite signal is defined as
calibration signal. The processing unit moreover decodes
the navigation message extracted from the calibration
signal in order to obtain the included time-of-week TOW
count. The TOW count indicates the main component of the
time of transmission T_{CTOT} of the ranging code. An epoch
and chip count performed by the tracking unit of the GPS
receiver provide in addition the millisecond and
submillisecond component of the time of transmission T_{CTOT}.
Further, the time of flight T_{CTOF} of the calibration signal
is estimated. To this end, for example the position of
the satellite transmitting the calibration signal at the
determined time of transmission T_{CTOT} is calculated from
orbit parameters for this satellite. The orbit parameters

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may be available at the receiver or be extracted as well from the decoded navigation message. The time of flight T_{CTOF} can then be estimated based on the determined satellite position and on the available initial reference position P_{init} of the receiver by dividing the distance between the two positions by the speed of light.

Next, the processing unit of the receiver determines at least a part of the time of transmission of the ranging code of all N other tracked signals. If the navigation message of an ith signal can be decoded, the complete time of transmission $T_{TOT,i}$ for the ith signal is obtained. If the navigation message cannot be decoded, at least a subcomponent $T_{MS,i}$ of the time of transmission can be determined. That is, if a bit synchronization is achieved, a sub 20ms component of the time of transmission T_{20ms} is obtained. Otherwise, the chip count by the tracking unit provides a subms component T_{1ms} of the time of transmission. The value of the variable i, i = 1 to N, identifies a respective, tracked signal and values associated to this signal.

Now, each of the N other tracked signals is verified by the processing unit of the GPS receiver one after the other in a calibration loop. In the calibration loop, the variable i is first set to 1 and incremented by 1 with each repetition.

The available initial reference position P_{init} and the determined time of transmission T_{CTOT} of the calibration signal are used for estimating the time-of-flight $T_{TOF,i}$ of the ith signal. For example, first the position of the ith satellite at the time of transmission T_{CTOT} of the calibration signal may be estimated based on the orbit

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parameters available at the receiver for the satellite which is assumed to transmit the ith signal. Then, the time of flight $T_{TOF,i}$ of the ith signal is estimated by dividing the distance between the estimated satellite position and on the available initial position P_{init} by the speed of light. The error in time for which the satellite position is calculated, i.e. the difference between the time of transmission T_{CTOT} of the calibration signal and the time of transmission of the ith signal, is around 40ms, which has a negligible effect on the time of flight.

Proceeding from the determined time of flight $T_{TOF,i}$, at least a subcomponent of the time of transmission of the ith signal is predicted. For this prediction, the processing unit differentiates between two cases.

In case the time of transmission $T_{TOT,i}$ was found for the ith signal, the time of transmission is predicted to be:

$$T_{TOT,i,pred} = T_{CTOT} + T_{CTOF} - T_{TOF,i} - Corrections .$$

In case the entire time of transmission $T_{TOT,i}$ was not found for the ith signal, but only a subcomponent $T_{MS,i}$ of this time of transmission $T_{TOT,i}$, the respective subcomponent is predicted to be:

$$T_{MS,i,pred} = \mathrm{mod}\left(T_{CTOT} + T_{CTOF} - T_{TOF,i} - Corrections, M\right)$$

The right hand side of the equation constitutes the residual of the division of T_{CTOT}-T_{CTOF}-$T_{TOF,i}$ by M, wherein the term T_{CTOT}-T_{CTOF}-$T_{TOF,i}$ may be corrected with a known correction value "Corrections". As explained above, M can be either 0.020 or 0.001. The value "Corrections" in the

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equation can, but does not have to be included. It may comprise e.g. ionospheric corrections, tropospheric corrections, group delay corrections, corrections of the satellite clock and relativistic corrections.

From the known error dP_{max} of the initial position P_{init}, the maximum error that may occur for the predicted time of transmission $T_{TOTmaxerror}$ is estimated to be $T_{TOTmaxerror} = 2*dP_{max}/c$, where c is the speed of light.

The actual prediction error is then compared with this maximum prediction error.

In case the time of transmission $T_{TOT,i}$ was found for the ith signal, the actual prediction error is compared with the maximum prediction error $T_{TOTmaxerror}$ according to the following equation:

$$abs\left(T_{TOT,i,pred} - T_{TOT,i}\right) < T_{TOTmaxerror}$$

Thereby, it is determined whether the determined time of transmission $T_{TOT,i}$ of the ith signal lies within the acceptable range:

$$\left(T_{TOT,i,pred} - T_{TOTmaxerror}, \; T_{TOT,i,pred} + T_{TOTmaxerror}\right).$$

In case only a subcomponent $T_{MS,i}$ of the time of transmission $T_{TOT,i}$ was determined for the ith signal, the actual prediction error is compared with the maximum prediction error $T_{TOTmaxerror}$ according to the following equation:

$$abs\left(T_{MS,i,pred} - T_{MS,i}\right) < T_{TOTmaxerror}$$

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If the respective equation is not true, the tracking of the ith signal is rejected, since it can be assumed that the tracking was not correct. The ith signal could be for example a strong signal of a wrong satellite which correlated better with the given code than a weak signal of the correct satellite.

If the respective equation is true, the tracking of the ith signal is not rejected. Before it is definitely accepted, however, an additional verification is carried out.

In the additional verification, the Doppler frequency range is checked for each satellite which was not rejected in the first verification.

The receiver measures to this end the frequency shift $f_{measurement,i}$ of the ith signal. Depending on the velocity of the respective satellite relative to the GPS receiver, the measured frequency will deviate from zero by a frequency shift $f_{measurement,i}$ due to the Doppler effect.

The available orbit parameters are used for determining for the satellite from which the ith signal is supposed to originate a range (f_{Dmin}, f_{Dmax}) within which the determined frequency shift $f_{measured,i}$ should lie in view of the satellite motion relative to the GPS receiver. For evaluating the available orbit parameters, the time of transmission T_{CTOT} of the calibration signal can be used again as reference time. The range should also take into account a maximum receiver velocity. The frequency will usually further be biased by the local clock inaccuracy. Since the receiver usually has an estimate Δf_{clock} of this

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inaccuracy, the possible overall frequency shift can be estimated as

$$\left(f_{min}, f_{max}\right) = \left(f_{Dmin} + f_{clock} - \Delta f_{clock}, f_{Dmax} + f_{clock} + \Delta f_{clock}\right).$$

The tracking of the ith signal is thus only validated in case the determined frequency shift $f_{measured,i}$ lies in addition in the range (f_{min}, f_{max}) determined for the satellite which transmitted the ith signal. Otherwise, the tracking of the ith signal is rejected as well.

When a tracking has been rejected or validated, the calibration loop is continued for the next tracked signal with i=i+1, until all N tracked signals other than the calibration signal are checked.

The correlation procedure and the described method can be repeated for those given codes for which the tracking was rejected.

It is to be noted that the described embodiment constitutes only one of a variety of possible embodiments of the invention.

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C l a i m s

1. Method for validating detected code modulated signals
    transmitted by beacons of a positioning system and
    received by a receiver of said positioning system,
    which beacon signals are detected based on a
    correlation procedure performed between a respective
    given code for a specific beacon and received beacon
    signals, said method comprising:
    - performing measurements for said detected beacon
      signals;
    - selecting at least one of said detected beacon
      signals as calibration signal;
    - determining at least one allowed range for results
      of measurements for detected beacon signals other
      than said calibration signal based on measurements
      for said detected calibration signal and on an
      available reference position of said receiver; and
    - rejecting each detection of a beacon signal for
      which results of performed measurements are
      outside of an allowed range determined for said
      measurements.

2. Method according to claim 1, wherein at least the
    detected beacon signal with the strongest signal
    level is selected as calibration signal.

3. Method according to claim 1 or 2, wherein said ranges
    are determined based in addition on orbit parameters
    available for said beacons.

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4.   Method according to one of the preceding claims,
     wherein said measurements for which a range is
     determined comprise at least a measurement of the
     code phase of the detected beacon signals.

5.   Method according to claim 4, wherein said code phase
     is determined based at least on an information on the
     time of transmission of a respective detected beacon
     signal, which information is comprised as data in
     said beacon signals.

6.   Method according to claim 4 or 5, wherein said code
     phase is determined based at least on a sub component
     of the time of transmission of a respective detected
     beacon signal, which sub component is obtained by
     detecting regularities in said received beacon
     signals.

7.   Method according to one of claims 4 to 6, wherein a
     range is determined for said code phase by predicting
     a code phase based on the code phase of said
     calibration signal, on an available reference
     position of said receiver and on available orbit
     parameters, and by adding and subtracting a possible
     error in said prediction.

8.   Method according to one of the preceding claims,
     wherein said measurements for which a range is
     determined comprise a measurement indicating a
     frequency shift in received beacon signals due to the
     relative velocity between the respective beacon and
     said receiver.

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9. Method according to one of the preceding claims,
    wherein said detected beacon signals are detected in
    a tracking process.

10. Receiver comprising
    - receiving means for receiving and detecting code
      modulated signals transmitted by beacons of a
      positioning system; and
    - processing means for carrying out the method
      according to one of the preceding claims.

11. Receiver according to claim 10, which receiver is a
    GPS (Global Positioning system) receiver or a Galileo
    receiver.

12. Electronic device comprising a receiver according to
    claim 10 or 11.

13. Electronic device according to claim 12, wherein said
    electronic device is a mobile terminal capable of
    connecting to a network.

14. Device comprising
    - means for receiving from a receiver information on
      code modulated signals transmitted by beacons of a
      positioning system and received and detected by
      said receiver; and
    - processing means for carrying out the method
      according to one claims 1 to 9.

15. Device according to claim 14, which device is a
    network element of a network.

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16. Positioning system comprising
    - a receiver comprising means for receiving code
      modulated signals transmitted by beacons, and
      means for providing information on received code
      modulated beacon signals; and
    - a device according to claim 14 or 15.

17. Positioning system comprising
    - a receiver according to claim 10 or 11; and
    - a device for providing assistance data to said
      receiver.

18. Positioning system according to claim 17, wherein
    said device is a network element of a network.

A b s t r a c t

The invention relates to method for validating detected
code modulated signals transmitted by beacons of a
positioning system and received by a receiver. In order
to enable such a validation, it is proposed that the
method comprises as a first step performing measurements
for the detected beacon signals. Then, at least one of
the detected beacon signals is selected as calibration
signal. In a next step, at least one allowed range for
results of measurements for detected beacon signals other
than said calibration signal are determined based on
measurements for the detected calibration signal and on
an available reference position of the receiver. Finally,
each detection of a beacon signal for which results of
performed measurements are outside of an allowed range is
rejected. The invention relates equally to a
corresponding receiver, to an electronic device
comprising such a receiver, to a device cooperating with
such a receiver and to a corresponding positioning
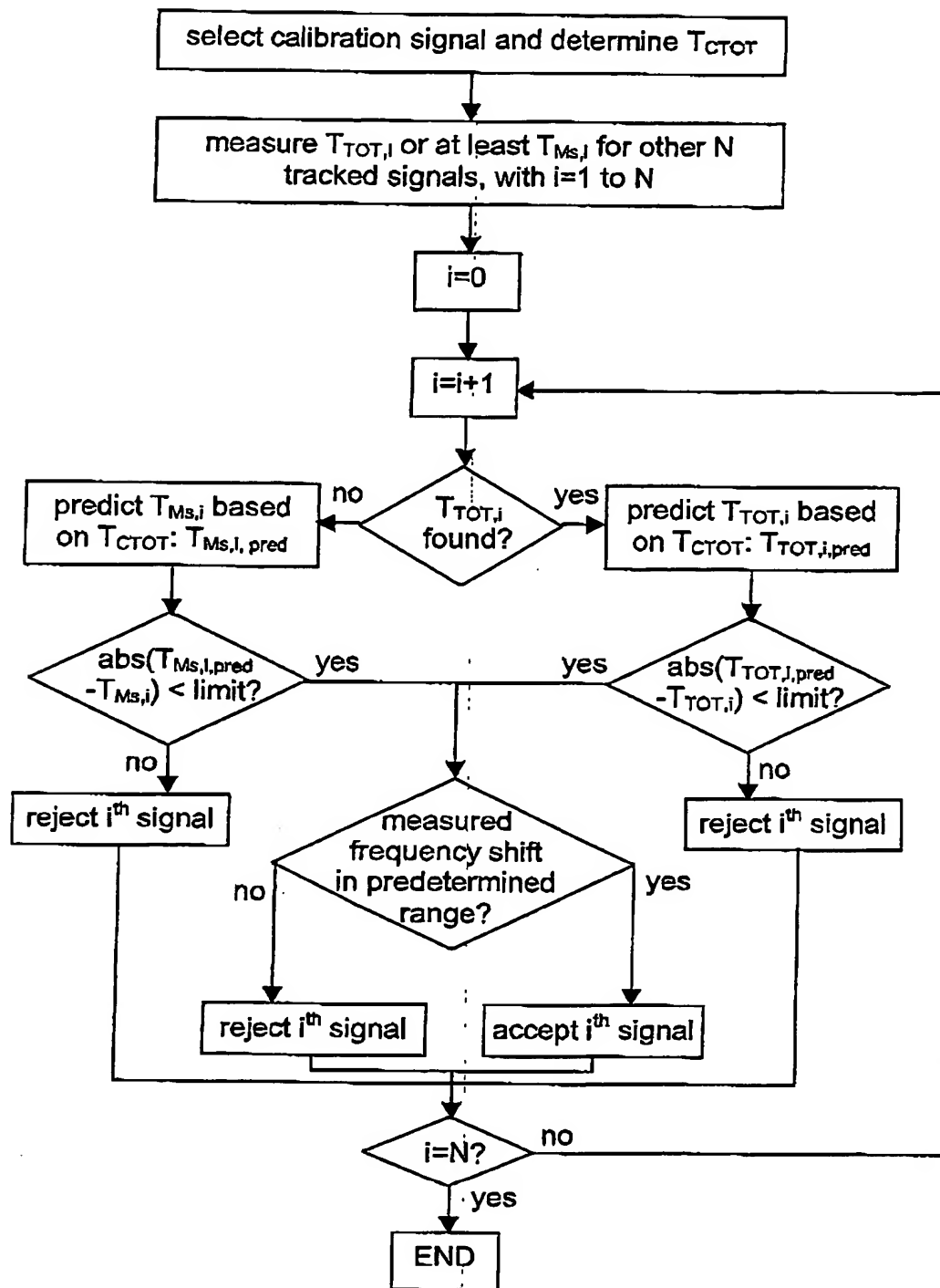system.

[For publication: Figure 1]

FIG. 1